

CLAIMS

1 1. A method for characterizing a contaminant in a fluid flow system, comprising the steps
2 of:

- 3 (a) injecting a conservative tracer and an interactive tracer into the flow
4 system at a first location;
- 5 (b) advecting the tracers along the flow system;
- 6 (c) extracting the tracers at a second location in the flow system;
- 7 (d) measuring the concentration of the extracted tracers over a period of time; and
- 8 (e) characterizing the contaminant from the concentrations of the tracers.

1 2. The method of claim 1 where the concentration is measured as a function of time.

1 3. The method of claim 1 wherein the characterizing includes detecting the presence of a
2 specific contaminant of interest in the fluid flow system.

1 4. The method of claim 1 wherein the characterizing includes locating a specific
2 contaminant of interest in the fluid flow system.

1 5. The method of claim 1 wherein the characterizing includes quantifying the amount of a
2 specific contaminant in the flow system.

1 6. The method of claim 1 wherein the tracers are advected by a fluid that does not interact
2 with the tracers or the contaminant.

1 7. The method of claim 1 wherein the interactive tracer is a partitioning tracer.

1 8. The method of claim 1 wherein the interactive tracer is a reactive tracer.

1 9. The method of claim 1 wherein a plurality of interactive tracers are injected.

1 10. A method for detecting the presence of a contaminant in a fluid flow system,
2 comprising the steps of:

- 3 (a) injecting a conservative tracer and an interactive tracer into the flow system at a
4 first location;
- 5 (b) advecting the tracers along the flow system with a fluid that does not interact
6 with the tracers;
- 7 (c) extracting the tracers at a second location in the flow system;
- 8 (d) measuring the concentration of the extracted tracers over a period of time; and
- 9 (e) detecting the presence of the contaminant from a comparison of the measured
10 concentrations.

1 11. The method of claim 10 where said concentration is measured as a function of time.

1 12. The method of claim 10 wherein the interactive tracer is a partitioning tracer.

1 13. The method of claim 10 wherein the interactive tracer is a reactive tracer.

1 14. The method of claim 10 wherein a plurality of interactive tracers are injected into the
2 fluid flow system.

1 15. A method for determining the location of a contaminant in a fluid flow system,
2 comprising the steps of:

- 3 (a) injecting a conservative tracer and a partitioning tracer into the flow system at a
4 first location;
- 5 (b) advecting the tracers along the flow system at a first velocity to create an
6 advection flow field;

- 1 (c) extracting the tracers at a second location in the flow system;
- 2 (d) introducing a perturbation to the advection flow field at a perturbation time by
3 changing and then re-establishing the advection flow at a second velocity,
4 which may be different than the first velocity, creating a unique change in the
5 concentration of the partition tracer;
- 6 (e) extracting the partitioning tracer as a function of time relative to the
7 perturbation time;
- 8 (f) measuring the concentration of the partitioning tracer as a function of the time;
9 and
- 10 (g) determining the location of contamination from the time of arrival of the
11 partitioning tracer relative to the perturbation time and the advection flow
12 velocity.

1 16. A method for determining the quantity of a contaminant in a fluid flow system,
2 comprising the steps of claim 1, wherein the quantity of extracted tracer is related to the
3 quantity of contaminant.

1 17. An apparatus for characterizing a contaminant in a fluid flow system, comprising:

- 2 (a) a tracer injection system for injecting known amounts of conservative and
3 interactive tracers into the flow system;
- 4 (b) an advection driving system for moving the tracers along the flow system;
- 5 (c) a tracer extraction system for removing the tracers from the fluid flow system;
- 6 (d) a measurement system for determining the concentration of the tracers extracted
7 from the fluid flow system; and
- 8 (e) a processor for analyzing the concentration measurements.

1 18. The apparatus of claim 17, wherein the injection system includes a container with a
2 valve holding tracers at pressure, whereby the tracers can be injected into the flow system by
3 depressurizing the container by opening the valve on the container.

1 19. The apparatus of claim 17, wherein the driving system includes a compressed gas
2 cylinder.

1 20. The apparatus of claim 17, wherein the measurement system includes a gas
2 chromatograph.